What’s the smallest part of spinach? A new experimental approach to the count/mass distinction

Sea Hee Choi & Tania Ionin
University of Illinois at Urbana-Champaign

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The count/mass distinction

- The count/mass distinction is linguistic.
- In English, the count/mass distinction is fully grammaticized:

<table>
<thead>
<tr>
<th>diagnostic</th>
<th>count nouns</th>
<th>mass nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>indefinite article <em>a</em> (count)</td>
<td>(\sqrt{a,\text{chair}} / \text{chocolate} / \text{bean})</td>
<td>(*\text{a,furniture} / \text{mustard} / \text{spinach})</td>
</tr>
<tr>
<td>plural marking (count)</td>
<td>(\sqrt{\text{chairs}} / \text{chocolates} / \text{beans})</td>
<td>(*\text{furnitures} / \text{mustards} / \text{spinaches})</td>
</tr>
<tr>
<td>ability to occur in bare (determiner-less) form (mass)</td>
<td>(*\text{I bought chair} / \text{bean}.)</td>
<td>(\sqrt{\text{I bought furniture} / \text{mustard} / \text{spinach} / \text{chocolate}.})</td>
</tr>
<tr>
<td>many (count) vs. much (mass)</td>
<td>(\text{many chairs} / \text{chocolates} / \text{beans})</td>
<td>(\text{much furniture} / \text{mustard} / \text{spinach} / \text{chocolate})</td>
</tr>
</tbody>
</table>
The object/substance contrast

• The object/substance distinction is cognitive: e.g., *chair* denotes an object, *mustard* - a substance.

  • a noun is atomic iff there exists a minimal unit that has the property denoted by the noun

• The minimal unit of 'chair' is a chair, but there is no minimal unit of ‘mustard’ (is it a drop? a spoonful? a jar?)
Relationship between the object/substance contrast and the count/mass distinction

• In plural-marking languages, the relationship between atomicity and count/mass morphosyntax is indirect:
  • *furniture* is object-denoting and atomic, yet mass

• And there is much variation both within and across languages with regard to ‘flexible’ nouns (Barner & Snedeker 2005)
  • *spinach* in mass English but count in French
  • *bean* is count in English but mass in Russian
  • *chocolate, stone, string* have both count and mass forms in English
The count/mass distinction in Generalized Classifier languages

• In Generalized Classifier (GC) languages such as Korean and Mandarin Chinese, there is debate about the existence of a grammatical count/mass distinction (Chierchia 1998, Cheng and Sybesma 1999, Kim 2005).

• Both object-denoting and substance-denoting nouns in GC languages behave very similarly:
  • all nouns can occur in bare form
  • all nouns combine with classifiers
  • plural marking is highly restricted in Mandarin (Iljic 1994, Li 1999) and optional (in most contexts) in Korean (Kim 2005, Kwon & Zribi-Hertz 2004)

• Yet GC languages may have markers of the count/mass distinction:
  • Classifiers in Mandarin (Cheng and Sybesma 1999)
  • Plural marking in Korean (Kim 2005)
The count/mass distinction in Generalized Classifier languages

• In GC languages, the relationship between atomicity and count/mass morphosyntax is much more direct than in plural-marking languages.

• In Korean, all atomic nouns can (optionally) combine with the plural marker -tul, while non-atomic nouns cannot (Kim 2005; experimental support in Choi, Ionin & Zhu 2018).

• In Mandarin, atomic vs. non-atomic nouns combine with different types of classifiers (Cheng & Sybesma 1998).
Noun categories examined in this study

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample noun</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Object-count</td>
<td>chair</td>
<td>Atomic nouns, count-cross-linguistically</td>
</tr>
<tr>
<td>2. Flexible-count</td>
<td>bean</td>
<td>Flexible nouns cross-linguistically, count in English</td>
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<td>Superordinate nouns, mass in English</td>
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<td>6. Substance-mass</td>
<td>mustard</td>
<td>Non-atomic nouns, mass cross-linguistically</td>
</tr>
</tbody>
</table>
How are morphosyntax and interpretation related?

• **Possibility 1: Morphosyntax drives interpretation. Within a given language...**
  • If a noun is count (*chair*), it is interpreted as atomic / object-denoting.
  • If a noun is mass (*mustard, furniture*), it is interpreted as non-atomic / substance-denoting.
  • If a noun is flexible (*chocolate*), it is optionally interpreted as either atomic or non-atomic.

• **Possibility 2: Interpretation drives morphosyntax. In all languages...**
  • Object-denoting nouns tend to be count, but even if they are mass (*furniture*), they are still interpreted as atomic.
  • Substance-denoting nouns tend to be mass.
  • Nouns which can potentially denote either objects or substances (*spinach, chocolate*) differ in their morphosyntax across languages, but still have a stable interpretation, regardless of whether they are count, mass or flexible within a given language.

• Prior literature lends support to both possibilities.
The object/substance rating task (Barner, Inagaki & Li 2009)

• Native English and native Japanese speakers rated 100 words presented in bare singular form as object, substance, both, or neither.

• Much agreement between the two languages in the object/substance ratings:
  • English count nouns mostly denoted objects.
  • English mass nouns mostly denoted substances.
  • Various types of flexible nouns fell in between.
The quantity judgment task (Barner & Snedeker 2005, and much subsequent work)

• The methodology: ask participants “Who has more X?”, where X is a count or a mass noun.
• The choice of pictures: two large objects vs. six small objects
• Judgment by number: select six small objects
• Judgment by volume: select two large objects
• Across studies, count, mass and flexible nouns have been tested, across both plural-marking and GC languages.
• Morphosyntactic form:
  • in plural-marking languages, count nouns presented in plural form, mass nouns – in singular form.
  • In GC languages, all nouns presented in bare form

NB: Cheung, Li & Barner (2009) also examined the contribution of classifiers in Mandarin: classifiers led to more judgments by number.
Schematized example: Who has more chairs?
Schematized example: Who has more mustard?
Schematized example: Who has more chocolate? Who has more chocolates?
Findings with native speakers of plural-marking languages

<table>
<thead>
<tr>
<th>Language / study</th>
<th>Count nouns ( (\textit{chairs}) )</th>
<th>Substance-mass nouns ( (\textit{mustard}) )</th>
<th>Object-mass nouns ( (\textit{furniture}) )</th>
<th>Within-English flexible nouns ( (\textit{chocolate(s)}) )</th>
<th>Flexible nouns that are mass in English, count in French ( (\textit{spinach}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>English (Barner &amp; Snedeker 2005)</td>
<td>By number</td>
<td>By volume</td>
<td>By number</td>
<td>chocolate: by volume</td>
<td></td>
</tr>
<tr>
<td>English (Barner et al. 2009)</td>
<td>By number</td>
<td>By volume</td>
<td></td>
<td>chocolate: by volume</td>
<td>chocolates: by number</td>
</tr>
<tr>
<td>English (Inagaki &amp; Barner 2009)</td>
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<td>By volume</td>
<td>By number</td>
<td>chocolate: by volume</td>
<td>chocolates: by number</td>
</tr>
<tr>
<td>French (Inagaki &amp; Barner 2009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mostly by number</td>
</tr>
<tr>
<td>English (MacDonald &amp; Carroll 2018)</td>
<td>By number</td>
<td>By volume</td>
<td>By number</td>
<td>chocolate: by volume</td>
<td>chocolates: by number</td>
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Findings with native speakers of GC languages

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<tr>
<td>Japanese (Barner et al. 2009)</td>
<td>By number</td>
<td>By volume</td>
<td></td>
<td>in between</td>
<td></td>
</tr>
<tr>
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<td>in between</td>
<td>mostly by number</td>
</tr>
<tr>
<td>Mandarin (Cheung et al. 2010)</td>
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<td>By volume</td>
<td></td>
<td>in between</td>
<td></td>
</tr>
<tr>
<td>Korean (MacDonald &amp; Carroll)</td>
<td>By number</td>
<td>By volume</td>
<td>By number</td>
<td>in between</td>
<td></td>
</tr>
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Interpretation is independent of morphosyntax for some noun classes

• Object-denoting nouns are always judged by number:
  • In English, both when they are count *(chairs)* and when mass *(furniture)*
  • In GC languages, where they are presented in bare form

• Substance-denoting nouns are always judged by volume:
  • In both English and GC languages
But interpretation of flexible nouns appears to be dependent on the morphosyntax

- In plural-marking languages, the judgment of flexible nouns is directly related to their morphosyntax:
  - *chocolate* (mass), *spinach* (mass in English) → judged by volume
  - *chocolates* (count), *spinach* (count in French) → judged by number

- In GC languages, the judgments fall in-between:
  - Nouns like *chocolate* and *spinach* are sometimes judged by number, sometimes by volume, with much variation.

- A possible task effect:
  - In English and French, the noun was presented in plural form if count and in singular form if mass, but in GC languages, the noun was always bare.
  - Could this be influencing the interpretation?
Study objectives

• Methodological objective:
  • To develop a task that directly asks participants about interpretation, targeting the concept of atomicity, and without providing any morphosyntactic cues.

• Theoretical objective:
  • To examine whether there are differences in the interpretation of flexible nouns between English and GC languages, in the absence of morphosyntactic cues.
## Noun categories tested

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<tr>
<th>Category</th>
<th>Sample noun</th>
<th>Explanation</th>
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<tbody>
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<tr>
<td>6. Substance-mass</td>
<td>mustard</td>
<td>Non-atomic nouns, mass cross-linguistically</td>
</tr>
</tbody>
</table>
Noun selection for the study

• Nine obligatorily plural-marking languages were surveyed ((English, Spanish, Russian, German, Greek, Brazilian Portuguese, Polish, French, Basque) in order to determine which nouns are flexible across languages.

• Frequency across the six categories of nouns was matched using the Corpus of Contemporary American English (COCA).

• No significant differences in frequency across conditions.
Two experiments

• Experiment 1: A Minimal Parts Identification Task (MPIT), administered online
  • Goal: to examine the interpretation of nouns as atomic or not
  • Participants: 20 native English speakers, 20 native Korean speakers, 20 native Mandarin speakers

• Experiment 2: A Grammaticality Judgment Task (GJT), administered online.
  • Goal: to establish which nouns are compatible with plural marking in English vs. in Korean (Mandarin was not tested, since plural marking is ungrammatical with all [-human] nouns).
  • Participants: 20 native English speakers and 20 native Korean speakers
  • (About half of the participants completed the MPIT a month before the GJT).
Grammaticality judgment task (GJT)

• Each noun was used in a sentence frame
  • The sentence frames were normed to be maximally neutral, not biasing towards either object or substance readings
  • Each noun was used in both singular and plural forms: e.g., *I read about string/strings in the library yesterday.*

• Counterbalancing across two experimental lists, so the same noun appeared only once within each list.

• Each list contained 48 target items (6 noun types × 8 tokens – 4 singular & 4 plural), plus 60 fillers.

• Participants rated each sentence on a scale from 1 to 4.

• The materials were translated from English into Korean.
GJT: descriptive results

<table>
<thead>
<tr>
<th>Mean rating</th>
<th>1.Count chair (s)</th>
<th>2.Fl-count bean(s)</th>
<th>3.Flexible chocolate(s)</th>
<th>4.Object-mass furniture(s)</th>
<th>5.Fl-mass spinach(es)</th>
<th>6.Mass mustard(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>English, Sing</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>English, PI -s</td>
<td>Blue</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
</tr>
<tr>
<td>Korean, Bare-sg</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
</tr>
<tr>
<td>Korean, PI -tul</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
</tr>
</tbody>
</table>
### Morphosyntax: summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample noun</th>
<th>English (-s)</th>
<th>Korean (-tul)</th>
<th>Mandarin (-men)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Object-count</td>
<td>chair</td>
<td>required</td>
<td>optional</td>
<td>disallowed</td>
</tr>
<tr>
<td>2. Flexible-count</td>
<td>bean</td>
<td>required</td>
<td>optional but</td>
<td>disallowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>dispreferred</td>
<td></td>
</tr>
<tr>
<td>3. Flexible</td>
<td>chocolate</td>
<td>optional</td>
<td>preferred</td>
<td>disallowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and</td>
<td>optional but</td>
<td>disallowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>preferred</td>
<td>dispreferred</td>
<td></td>
</tr>
<tr>
<td>4. Object-mass</td>
<td>furniture</td>
<td>disallowed</td>
<td>optional</td>
<td>disallowed</td>
</tr>
<tr>
<td>5. Flexible-mass</td>
<td>spinach</td>
<td>disallowed</td>
<td>optional but</td>
<td>disallowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>dispreferred</td>
<td></td>
</tr>
<tr>
<td>6. Substance-mass</td>
<td>mustard</td>
<td>disallowed</td>
<td>disallowed</td>
<td>disallowed</td>
</tr>
</tbody>
</table>
Minimal Parts Identification Task (MPIT)

• A new task, testing interpretation without giving morphosyntax cues.
• Each noun was presented in bare form.
• Participants were asked: ‘Does X have a minimal unit?’
  • Does *chair* have a minimal unit?
  • Does *chocolate* have a minimal unit?
  • Does *water* have a minimal unit?
• Similar to the object/substance rating task (Barner et al. 2009), but asking directly about atomicity.
• If participants answered ‘Yes’, they were asked to identify what the minimal unit is (these results are not reported today).
• 48 test items (6 noun type categories X 8 tokens)
• The materials were translated from English into Korean and Mandarin.
MPIT instructions given to participants

• When we see something, we can sometimes think of its minimal (smallest) unit. For example, the minimal unit of table is a table: if you divide a table in half, it cannot function as a table anymore. However, the minimal (smallest) unit of water is vague (it is unclear what the minimal (smallest) unit is): if we divide water in half, it will still be water. For each item in this task, you will see a word and two questions about the given word. In the first question, please indicate whether you can think of the minimal (smallest) unit for this word, by clicking either ‘yes’ (you can think of the minimal unit, as with table), or ‘no’ (you cannot think of the minimal unit, or the minimal unit is vague, as with water). In the second question, you will see another question which will ask what is the minimal (smallest) unit of the given object/substance. If you answered “yes” to the first question, then, please type what you think the minimal unit is. For example, if you see the word “table”, you will click ‘yes’ and type ‘a table’. If you answered “no” to the first question, please type “N/A” “vague” or “none” in thesecond question.
MPIT results

<table>
<thead>
<tr>
<th>Category</th>
<th>English</th>
<th>Korean</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Count chair(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.Fl-count bean(s)</td>
<td></td>
<td></td>
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<td>4.Object-mass furniture(s)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6.Mass mustard(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MPIT: statistical analysis

• Mixed effects logistic regression
• Dependent variable: response (Yes minimal unit = 1, No minimal unit = 0)
• Fixed factors:
  • Group (3 levels: English, Korean, Mandarin), with Helmert coding (English vs. GC; Korean vs. Mandarin)
  • Category (6 levels, for 6 noun types), with contrast coding
• Random factors: subjects (N=60), items (N=48)

• To explore the source of significant interactions, Bonferroni pairwise comparisons were done on the model output.
MPIT: significant results

- Significant effect of Group (English vs. GC): z=2.81, p<.01.
- Significant effect of Category (category 1 (count) vs. categories 2-6): z=15.81, p<.01
- Significant effect of Category (category 2 (flexible-count) vs. categories 3-6): z=8.53, p<.01
- Significant effect of Category (category 3 (flexible) vs. categories 4-6): z=-4.19, p<01
- Significant interaction between Group (English vs. GC) and Category (category 2 (flexible-count) vs. categories 3-6): z=-2.05, p=.04
- Significant interaction between Group (English vs. GC) and Category (category 3 (flexible) vs. categories 4-6): z=-2.53, p=.01
- Marginal interaction between Group (Korean vs. Mandarin) and Category (category 4 (object-mass) vs. categories 5-6): z=1.75, p=.08
Pairwise comparisons for each category across groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample noun</th>
<th>Group comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Object-count</td>
<td>chair</td>
<td>English = Korean = Mandarin</td>
</tr>
<tr>
<td>2. Flexible-count</td>
<td>bean</td>
<td>English = Korean = Mandarin</td>
</tr>
<tr>
<td>3. Flexible</td>
<td>chocolate</td>
<td>English = Korean = Mandarin</td>
</tr>
<tr>
<td>4. Object-mass</td>
<td>furniture</td>
<td>English = Korean ≤ Mandarin, English &lt; Mandarin</td>
</tr>
<tr>
<td>5. Flexible-mass</td>
<td>spinach</td>
<td>English = Korean, Korean = Mandarin, English ≤ Mandarin</td>
</tr>
<tr>
<td>6. Substance-mass</td>
<td>mustard</td>
<td>English = Korean = Mandarin</td>
</tr>
</tbody>
</table>
Pairwise comparisons for each group, across categories

<table>
<thead>
<tr>
<th>Group</th>
<th>Group comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>count &gt; flexible-count &gt; flexible = object-mass = flexible-mass &gt; mass</td>
</tr>
<tr>
<td>Korean</td>
<td>count &gt; flexible-count, flexible, object-mass, flexible-mass, mass flexible-count = flexible-mass &gt; flexible, object-mass, mass flexible = flexible-mass = object-mass &gt; mass</td>
</tr>
<tr>
<td>Mandarin</td>
<td>count &gt; flexible-count, flexible, object-mass, flexible-mass, mass flexible-count = object-mass &gt; flexible, flexible-mass, mass flexible = flexible-mass = object-mass &gt; mass</td>
</tr>
</tbody>
</table>
Discussion of MPIT findings

• There are many similarities between the three groups:
  • Highest rates of ‘Yes, minimal unit’ responses for count nouns, lowest for substance-mass nouns.
  • The other four noun types pattern in between, with slight variations across languages.
• The English and Korean group do not differ on any category, despite clear differences in morphosyntax.
• The Mandarin group gives more ‘Yes, minimal unit’ responses overall, but this reaches significance only in the object-mass and flexible-mass categories.
Does morphosyntax drive interpretation?

• Mostly, no.
  • In English, there is not a binary divide between count and mass nouns with regard to interpretation.
  • The responses in Korean are nearly identical to those in English, despite clear cross-linguistic differences (plural marking is optional for nearly all of the categories in Korean).

• However, morphosyntax may play a slight role:
  • In English, count and flexible-count nouns do receive the highest rates of ‘Yes, minimal unit’ responses; however, there are still differences between the different types of mass nouns.
  • Mandarin speakers give the highest rates of ‘Yes, minimal unit’ responses overall – perhaps related to the highly restricted plural marking in Mandarin??
Comparisons to the findings from the quantity judgment task, QJT (Barner & Snedeker 2005, and subsequent literature)

• Count and substance-mass nouns: very similar findings
  • QJT: judged by number (count) vs. volume (mass)
  • MPIT: judged as having minimal units (count) vs. not having them (mass)

• Object-mass nouns: surprisingly different findings
  • QJT: judged by number
  • MPIT: patterned in-between

• Flexible nouns: much more cross-linguistic similarity with the MPIT than the QJT:
  • QJT: interpretation depends on the morphosyntax
  • MPIT: similar results in all three languages, with in-between rates of ‘Yes, minimal unit’ judgments
Limitations of the MPIT

• The MPIT may not have worked very well for object-mass nouns like *furniture*:
  • Analysis in terms of atomicity: *furniture* has stable minimal parts (a piece of furniture such as chair or table is furniture, but a chair/table part is not).
  • Participants’ interpretation may have been that *furniture* does not have stable minimal parts (because it could be a chair, table, couch, etc. – not always one thing, as with *chair*).

• The MPIT may not have succeeded in getting away from morphosyntax entirely in the case of flexible nouns like *chocolate*:
  • By presenting the noun in bare form (*chocolate*, not *chocolates*), we may have biased the participants towards the substance interpretation.
  • This would explain why flexible nouns patterned with flexible-mass rather than flexible-count nouns in English (but would not explain why this pattern also obtained in Korean!)
Conclusion

• The findings provide evidence that when morphosyntactic cues are absent, interpretation of nouns is remarkably similar across very different languages.

• Interpretation drives morphosyntax, not the other way around:
  • Atomic, object-denoting nouns are count.
  • Non-atomic, substance-denoting nouns are mass.
  • Nouns that can potentially denote either objects or substances are flexible within and/or across languages.
Future directions

• Analyze the qualitative part of the results: the responses participants gave for what constitutes a minimal unit.
  • When participants say “Yes, minimal unit” for substance-denoting nouns, what responses do they give, and are these responses similar across individuals?

• Modify the MPIT instructions: perhaps ask, for each X, whether half of X is still X? (for chair, furniture – no; for water, mustard – yes; for spinach, chocolate – maybe).

• Administer MPIT and GJT to the same group of participants, and look for correlations between the two tasks: e.g., in Korean, does grammaticality of -tul correlate with Yes, minimal unit responses?
Thank you!

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